

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
10 April 2003 (10.04.2003)

PCT

(10) International Publication Number  
**WO 03/030217 A3**

(51) International Patent Classification<sup>7</sup>: **H01L 29/00**

(21) International Application Number: PCT/US02/31253

(22) International Filing Date:  
30 September 2002 (30.09.2002)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:  
09/972,825 2 October 2001 (02.10.2001) US

(71) Applicant: **ACTEL CORPORATION** [US/US]; 955  
East Arques Avenue, Sunnyvale, CA 94086 (US).

(72) Inventors: **HAWLEY, Frank, W.**; 1360 Capri Drive,  
Campbell, CA 95008 (US). **MCCOLLUM, John, L.**;  
19180 Merribrook Drive, Saratoga, CA 95070 (US).  
**RANAWEERA, Jeewika, C.**; 1480 Via Cancion, San  
Jose, CA 95128 (US).

(74) Agent: **COPPES-GATHY, Nicole, E.**; Sierra Patent  
Group, Ltd., P.O. Box 6149, Stateline, NV 89449 (US).

(81) Designated States (*national*): AE, AG, AL, AM, AT, AU,  
AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU,  
CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH,  
GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC,  
LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW,  
MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG,  
SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VN,  
YU, ZA, ZM, ZW.

(84) Designated States (*regional*): ARIPO patent (GH, GM,  
KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW),  
Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),  
European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE,  
ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, SK,  
TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ,  
GW, ML, MR, NE, SN, TD, TG).

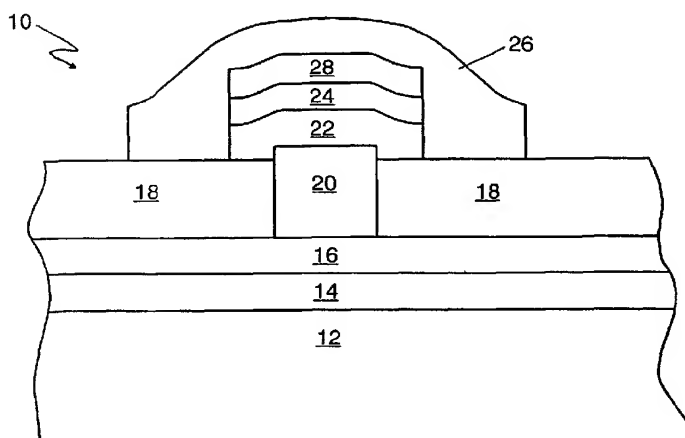
**Published:**

— with international search report

(88) Date of publication of the international search report:  
10 July 2003

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: METAL-TO-METAL ANTIFUSE EMPLOYING CARBON-CONTAINING ANTIFUSE MATERIAL



(57) Abstract: A metal-to-metal antifuse (22) is disposed between two metal interconnect layers in an integrated circuit. An insulating layer (18) is disposed above a lower metal interconnect layer (16). The insulating layer includes a via formed therethrough containing a tungsten plug (20) in electrical contact with the lower metal interconnect layer. The tungsten plug forms a lower electrode of the antifuse. The upper surface of the tungsten plug is planarized with the upper surface of the insulating layer. In a first embodiment, an antifuse material layer (22) comprising amorphous carbon, amorphous carbon doped with hydrogen or fluorine, or amorphous silicon carbide is disposed above the upper surface of the tungsten plug. A layer of a barrier metal (24) disposed over the antifuse material layer forms an upper electrode of the antifuse. An oxide (28) or tungsten hard mask provides high etch selectivity and the possibility to etch barrier metals without affecting the dielectric constant value and mechanical properties of the antifuse material. In a second embodiment, a layer of barrier material is disposed between the top surface of the tungsten plug and the antifuse material layer. An adhesion-promoting layer may be used where amorphous carbon is used as the antifuse material layer.



WO 03/030217 A3

# INTERNATIONAL SEARCH REPORT

International application No.

PCT/US02/31253

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : H01L 29/00

US CL : 257/530

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 257/530, 529, 50, 76

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched  
IEEE Transactions

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
Please See Continuation Sheet

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	LIU et al, A New Metal-to-Metal Antifuse with Amorphous Carbon," IEEE Electr. , Device Lett., Vol. 19, No. 9, September 1998, pages 317-319.	1-20, 24-33
Y,P	US 2002/0100907 A1 (WANG) 01 August 2002 (01.08.2002), pages 1-3.	1-33
Y	US 5,181,096 A (FOROUHI) 19 January 1993 (19.01.1993), column 7, lines 61-67; column 8, lines 1-6, 56-59.	21, 23, 32
Y	US 6,114,714 A (GANGOPADHYAY) 05 September 2000 (05.09.2000), column 4, lines 50-67.	2, 3, 14, 30
Y	US 5,365,104 A (GODINHO et al) 15 November 1994 (15.11.1994), column 5, lines 60-65.	4, 24

☐ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

* Special categories of cited documents:	
"A" document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"E" earlier application or patent published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	"&" document member of the same patent family

Date of the actual completion of the international search

20 November 2002 (20.11.2002)

Date of mailing of the international search report

03 APR 2003

Name and mailing address of the ISA/US

Commissioner of Patents and Trademarks  
Box PCT  
Washington, D.C. 20231

Facsimile No. (703) 305-3230

Authorized officer

Thomas Magee

Telephone No. (703) 308-0956

*Reserve Patent*

# INTERNATIONAL SEARCH REPORT

International application No.

PCT/US02/31253

## Continuation of B. FIELDS SEARCHED Item 3:

USPTO APS EAST

search terms: antifuse, insulating layers, tungsten plug, amorphous carbon, silicon carbide, barrier layers